Building the Future Air Force: Analysis of Platform versus Weapon Development

A Monograph

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This monograph proposes that platform development and employment is more important than weapon development and employment on the modern battlefield. The historical analysis examines the Air Force's conceptualization of warfare, as derived from both the doctrine and national policies preceding the Korean, Vietnam, and Gulf Wars. The conceptualization of future warfare informed the development and acquisition of both platforms and weapons employed during the previously mentioned conflicts. The monograph assesses the platforms and weapons against several interdependent criteria. Specifically, the analysis assesses platform survivability, flexibility, and payload; and weapon yield and precision. The monograph reveals the lag between security policy changes and the acquisition of new platforms and weapons, which enable the policy. This delay constrains the nature of warfare in a given conflict, and limits the effectiveness of the stated policy. The interval is even greater for platforms, making platform development more important than weapon development. Based on the unpredictable nature of warfare, adaptable platforms prove most valuable on the modern battlefield.

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Abstract

Building the Future Air Force: Analysis of Platform versus Weapon Development, by Major Ryan W. Ellis, USAF, 59 pages.

This monograph proposes that platform development and employment is more important than weapon development and employment on the modern battlefield. The historical analysis examines the Air Force's conceptualization of warfare, as derived from both the doctrine and national policies preceding the Korean, Vietnam, and Gulf Wars. The conceptualization of future warfare informed the development and acquisition of both platforms and weapons employed during the previously mentioned conflicts. The monograph assesses the platforms and weapons against several interdependent criteria. Specifically, the analysis assesses platform survivability, flexibility, and payload; and weapon yield and precision. The monograph reveals the lag between security policy changes and the acquisition of new platforms and weapons, which enable the policy. This delay constrains the nature of warfare in a given conflict, and limits the effectiveness of the stated policy. The interval is even greater for platforms, making platform development more important than weapon development. Based on the unpredictable nature of warfare, adaptable platforms prove most valuable on the modern battlefield.

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Acronyms

CENTAF	United States Air Forces Central
CEP	Circular Error Probable
ELINT	Electronic Intelligence
EOGB	Electro-Optical Guided Bomb
GBU	Guided Bomb Unit
IFF	Identification Friend or Foe
IR	Infrared
JCS	Joint Chiefs of Staff
LANTIRN	Low Altitude Navigation and Targeting Infrared for Night
LGB	Laser Guided Bomb
MOU	Memorandum of Understanding
PGM	Precision Guided Munition
SAC	Strategic Air Command
SAM	Surface to Air Missile
SHORAN	Short-Range Navigation
TAC	Tactical Air Command
TOT	Time on Target
USAF	United States Air Force

Introduction

> Tools, or weapons, if only the right ones can be discovered, form 99 percent of victory … Strategy, command, leadership, courage, discipline, supply, organization and all the moral and physical paraphernalia of war are nothing to a high superiority of weapons—at most they go to form the one percent which make the whole possible.
>
> —J. F. C. Fuller, *Armament and History*

The United States Air Force (USAF) is dependent on its weapon systems, or tools, to conduct warfare. These tools are continually pushing the limits of technology. New fifth generation fighters employ stealth technology allowing them to better evade enemy defenses and deliver weapons at closer range. On the other hand, "dumb" iron bombs have progressed to precision munitions guided to their targets by everything from lasers and advanced internal navigation systems to using the space-based Global Positioning System. These advances are costly, and future military budgets in the United States are uncertain.

The Air Force acknowledges that the future reality is one with "an enduring fiscally constrained environment."[1] In this environment, the service "must invest in the force required today and invest in the force we will need tomorrow."[2] Balancing these competing interests requires careful analysis to determine the future requirements within the budget constraints. In a fiscally constrained environment, it is responsible to ask the question, does platform or weapon development and employment provide greater effectiveness on the modern battlefield?

Methodology

The first step to answering the question is clarifying terminology, specifically defining the modern battlefield, and identifying characteristics of platforms and weapons. With terms

[1] Department of the Air Force, *USAF Strategic Master Plan* (United States Air Force, 2015), 17.

[2] Department of the Air Force, *Fiscal Year 2016 Air Force Posture Statement* (United States Air Force, 2015), 18.

identified, the analysis turns to historical case studies to assess the merits of platform and weapon development. Each case study examines the doctrine and national defense policy of the era to derive the Air Force's conceptualization warfare, which drives platform and weapon development. Then the investigation inspects the platforms and weapons themselves, using the characteristics below to evaluate platform and weapon effectiveness in that period's version of the "modern" battlefield. The study closes with conclusions on the relative importance of weapon and platform development.

Effectiveness on the Modern Battlefield

There are two aspects to clarify in the phrase *effectiveness on the modern battlefield*; defining both *effectiveness,* and *modern battlefield*. Carl Von Clausewitz famously wrote, "War is simply a continuation of political intercourse, with the addition of other means."[3] He continued this line of thought stating, "If war is part of policy, policy will determine its character. As policy becomes more ambitious and vigorous, so will war."[4] In this vein, policy makers determine the nature of warfare and drive the effects required from the military. For airpower to be effective in conflict, it must attain the efficacy policy makers require. Complicating the requirement is the dynamic nature of war. Policy will change throughout a conflict, and those policy changes will transform the character of the war. The variation in war requires diverse effects from military forces. These changing effects require flexibility amongst military forces. The more flexible the force, the more effective at fulfilling policy requirements. "Operational mission effectiveness is an appropriate utility proxy that is defined as 'the ability of the air vehicle to accomplish the mission objectives and avoid being killed while doing so.' This metric includes both the ability of

[3] Carl von Clausewitz, *On War*, ed. and trans. Peter Paret and Michael Howard (Princeton, NJ: Princeton University Press, 1976), 605.

[4] Carl von Clausewitz, *On War*, 606.

the aircraft to defend itself against the threat ("survivability") and the 'offensive (end game) ability' to accomplish the mission objectives."[5] Policy drives objectives. Effectiveness requires survivability and efficacy. Versatile policy requirements demand flexible responses to accomplish them. The modern battlefield further complicates policy demands.

The modern battlefield is a complex environment growing more varied with time. "Complexity and rapid change characterize today's strategic environment, driven by globalization, the diffusion of technology, and demographic shifts."[6] The National Security Strategy directs the military to "remain ready to deter and defeat threats to the homeland, including against missile, cyber, and terrorist attacks, while mitigating the effects of potential attacks."[7] Given the diversity of political objectives and complexity of the environment, the modern battlefield appears unpredictable. To scope the analysis below, the modern battlefield is limited to the physical domains, but makes no assumption about the intensity of the conflict. With a common understanding of effectiveness on the modern battlefield, the analysis turns to establishing criteria to examine weapons and platforms.

Weapons versus Platforms

The following section strives to draw a distinct line between platforms and weapons before establishing the most important characteristics of each for the subsequent historical analysis. Modern air forces rely on equipment composed of complex systems working together to provide an effect on the battlefield. The doctrinal definition of weapon systems are "a

[5] National Research Council, *Future Air Force Needs for Survivability* (Washington, DC: National Academies Press, 2006), 89.

[6] Martin Dempsey, *The National Military Strategy of the United States of America*, (Washington, DC: Government Printing Office, 2015), 1.

[7] Barack Obama, *National Security Strategy* (Washington, DC: The White House, February 2015), 7.

combination of one or more weapons with all related equipment, materials, services, personnel, and means of delivery and deployment (if applicable) required for self-sufficiency."[8] Webster's dictionary defines a platform as "a vehicle (as a satellite or aircraft) used for a particular purpose or to carry a usually specified kind of equipment."[9] Distilling these definitions down, the following analysis defines a platform as a recoverable and reusable vehicle, and the necessary equipment or sensors to deliver or deploy a weapon. This definition includes traditional manned aircraft, as well as unmanned aircraft systems. The analysis also includes the sensors or other cueing equipment required to employ the weapon as part of the platform. One platform with the proper sensors can provide cueing and targeting information for the weapons on other platforms.

Weapons vary in type, from guns and cannons to missiles and bombs, all carried by various airborne platforms. The research question implies that analysis will focus on weapons carried by airborne platforms and excludes intercontinental ballistic missiles. The study below also excludes air-launched cruise missiles and other expensive standoff weapons. Historical analysis shows that standoff weapons and the current B-2 bomber fleet cannot sustain the intensity required to wage an air campaign for more than a few days.[10] This highlights the requirement for a weapon system that is capable of entering an enemy's air defense engagement zone and employing weapons if the USAF is to provide the efficacy required from policy makers. The following paragraphs focus on the specific characteristics of the weapons and platforms for further analysis.

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[8] Joint Publication 3-0, *Joint Operations* (Washington, DC: Government Printing Office, 2011), GL-18.

[9] Merriam Webster's Dictionary Online, "platform," accessed January 16, 2016, http://www.merriam-webster.com/dictionary/platform.

[10] Thomas Hamilton, *Expendable Missiles vs. Reusable Platform Costs and Historical Data* (Santa Monica, CA: RAND Corporation, 2012), 5.

Platform and Weapon Characteristics

The Committee on Future Air Force Needs for Survivability detailed several design variables including; aircraft speed, observability, payload, and weapon lethality.[11] Speed and observability, or signature, are "both primary factors in determining survivability." [12] Survivability is the first platform characteristic. One addition characteristic not provided by the committee is platform flexibility. This variable directly influences the effectiveness on the battlefield, as multi-mission platforms increase the options available to military planners and policy makers alike. The platform payload is the last platform characteristic considered. Payload affects the types and size of weapons a platform can employ, and therefore, the effects available to the planners or policy makers. The last characteristic listed is weapon lethality. For the study below, weapon lethality divides into two subcomponents; weapon precision, and weapon yield. In sum, the five variables for historical analysis are platform survivability, flexibility, payload, weapon yield, and precision.

Platform Survivability

Platform survivability is critical to airpower's efficacy during any conflict. "The reduction in the efficacy of airpower because of the lack of aircraft survivability can have a disastrous effect on the campaign. The increasing intensity and sophistication of air defense systems will exacerbate this situation. Survivability cannot be ignored — its importance will not go away."[13] Robert Ball defines survivability "as the capability of an aircraft to avoid or

[11] National Research Council, *Future Air Force Needs for Survivability* (Washington, DC: National Academies Press, 2006), 92.

[12] National Research Council, *Future Air Force Needs for Survivability*, 61.

[13] Robert E. Ball, *The Fundamentals of Aircraft Combat Survivability Analysis and Design*, 2nd ed., AIAA Education Series (Reston, VA: American Institute of Aeronautics and Astronautics, 2003), 114.

withstand a man-made hostile environment."[14] Ball divides survivability into two components; susceptibility, and vulnerability.[15] The analysis below only considers susceptibility, or the ability to avoid air defenses. Susceptibility relies on speed and stealth, or minimizing the signature of the platform.[16] The amount of time a threat system has to track and resolve a targeting solution is the key factor to survivability. "Aircraft with hypersonic speed can survive against highly capable current threats because air defenses are not expected to have time to engage them successfully at their achievable observability; it is also clear that very stealthy vehicles can survive because air defenses cannot find them in time to track them and engage them."[17] This assessment should not judge speed and signature reduction as equals. "Improvements in stealth reduce the threat's defended area and have a greater utility in defeating SAMs [surface-to-air missile] than do increases in speed. Increases in speed and stealth both reduce the exposure time in the threat's defended area; increases in speed have a greater utility in defeating airborne interceptors than do just improvements in stealth alone."[18] Speed and signature reduction each has its own niche depending on the desired mission of the platform. The tradeoff between the two reveals an interdependency between survivability and flexibility.

[14] Ball, *The Fundamentals of Aircraft Combat Survivability*, 1.

[15] Ball, *The Fundamentals of Aircraft Combat Survivability*, 1.

[16] National Research Council, *Future Air Force Needs for Survivability*, 15.

[17] National Research Council, *Future Air Force Needs for Survivability*, 61.

[18] National Research Council, *Future Air Force Needs for Survivability*, 61.

Platform Flexibility

Flexibility is one of the doctrinal tenets of airpower, and acknowledges the versatility airpower provides to operational commanders.[19] Specifically, "flexibility allows airpower to exploit mass and maneuver simultaneously," allowing airpower to "quickly and decisively" shift between campaign objectives or desired effects.[20] The tenet of flexibility applies across the entire force structure of an air force. Within that force structure, flexibility also applies to individual platforms. A platform fulfilling an escort role one day and used for close air support the next exhibits flexibility. This change in mission with one platform allows the USAF to quickly shift between desired effects and increase the options available to planners. Unfortunately, this requirement does have tradeoffs, such as the impact on survivability. Different threats emphasize varying survivability characteristics. It is not possible to optimize one platform against all threats. Another requirement for flexibility is the platform's ability to employ a variety of weapons to conduct multiple mission types. This increases the payload of the platform, which creates design constraints and leads to increased platform signature.[21]The platforms must survive for airpower to maintain its efficacy. An interdependency between survivability, flexibility, and payload emerges from the discussion.

Platform Payload

Platform payload relates to flexibility in terms of the types of weapons a platform can carry, as well as the efficacy of a given platform based on the number of weapons it can carry. The impact of the platforms payload is pervasive. As "the type, effectiveness, and number of

[19] Air Force Doctrine Vol. 1, *Basic Doctrine* (Washington, DC: Government Printing Office, 2015), 65, accessed March 14, 2016, https://doctrine.af.mil/download.jsp?filename= Volume-1-Basic-Doctrine.pdf.

[20] Air Force Doctrine Vol. 1, *Basic Doctrine*, 70.

[21] National Research Council, *Future Air Force Needs for Survivability*, 40-41.

weapons carried influence weapon delivery tactics and the number of sorties required to kill the target. The more sorties required to get the job done, the more likely the loss of aircraft." [22] Increasing the payload also affects survivability. The need to reduce susceptibility creates a requirement for stealth. A reduced radar cross-section creates "the requirement to carry ordnance internally to reduce radar signature."[23] The threshold for stealth might conflict with the payload constraint of certain platforms and missions.[24] Platforms designed for close air support, interdiction, and strategic attack necessitate large payloads.[25] A large payload requirement either restricts the ability to use internal weapons stations, or forces the overall platform size to increase, limiting other design parameters. The nature of the weapons themselves also influences the suitability of a platform's payload. Weapons that are more lethal allow for either smaller payloads, or reduced total number of aircraft.

Weapon Yield

A weapon's required yield depends on the desired effect and accuracy of the weapon. Early in its history, airpower struggled to deliver on its promise of precision bombing. Tactics changed and "warhead lethality was being used to compensate for inaccurate delivery."[26] Now that reliable precision munitions are a reality, the opposite trend is occurring. Weapon yields are dropping in order to limit the overall destructiveness of war while still achieving desired effects. During Operation Iraqi Freedom, this trend reached a pinnacle as the USAF started using cement

[22] Ball, *The Fundamentals of Aircraft Combat Survivability*, 46.

[23] Ball, *The Fundamentals of Aircraft Combat Survivability*, 46.

[24] Ball, *The Fundamentals of Aircraft Combat Survivability*, xxxiii.

[25] Ball, *The Fundamentals of Aircraft Combat Survivability*, 239, 241, 246.

[26] Paul G. Gillespie, *Weapons of Choice: The Development of Precision Guided Munitions* (Tuscaloosa: University of Alabama Press, 2006), 127.

munitions with no explosives at all.[27] This extreme highlights that a weapon with no explosive yield can meet policy makers' desired intent, as long as it is precise.

Weapon Precision

Precision weapons provide more policy options to national leaders with an ability to hold nearly any target at risk. With increased precision, planners can still target structures in highly populated areas while minimizing civilian casualties. Precision weapons allow political leadership to select military options that "fit the tone and intent of the political discourse."[28] Weapon precision also affects the battlefield directly. The accuracy of these weapons, when combined with airpower's speed, range, and flexibility, alters the concept of massed forces. For airpower, mass is not solely based on the quantity of forces and materiel committed, but also the ability to congregate the effect of "mass faster than other forces."[29] An integral part of this massing is precision weapons and the effect of minimizing the number of weapons required to strike a given target.

These five characteristics above provide a lens to compare platform and weapon effectiveness in the historical cases that follow. There are clear interdependencies amongst all of the variables. The intent is not to make a judgement about the tradeoffs of parameters, but to assess the development decisions and their overall effectiveness on the battlefield. While they are not all inclusive, the parameters provide a solid baseline to derive conclusions about the merits of developing platforms or weapons.

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[27] Scripps Howard News Service, "Cement Bombs Crush Rather than Explode," *Journal-Gazette,* April 9, 2003, accessed March 9, 2016, https://lumen.cgsccarl.com/login?url= http://search.proquest.com.lumen.cgsccarl.com/docview/411066031?accountid=28992.

[28] S. J. Dudzinsky and James Digby, *Qualitative Constraints on Conventional Armaments: An Emerging Issue* (Santa Monica, CA: RAND Corporation, 1976), 43.

[29] Air Force Doctrine Vol. 1, *Basic Doctrine*, 54.

Conventional War in the Nuclear Age: The Korean War

The United States closely examined its defense posture and previous military assumptions following World War II. The chance that an adversary would use weapons of mass destruction, specifically atomic and biological weapons, invalidated the assumption of an unscathed homeland and radically changed the traditional peacetime strategy.[30] The shift in national security thinking was "redefined in relation to the facts of modern war," specifically "not losing the first campaign of the war if the loss would mean that the country would be invaded and occupied."[31] In order to accomplish this goal, the President's Air Policy Commission concluded, "our military security must be based on air power."[32] The emphasis on using airpower to guarantee national defense helped ensure resources for research and development, but the strategy pursued would determine the nature of the force available in future conflicts.

The specific strategy for homeland defense drove future acquisition requirements. To determine the type of airpower desired, the President's Air Policy Commission first assessed the overall threat, and determined another nation possessing a large quantity of atomic weapons was the seminal event around which to plan.[33] The commission set a planning date of January 1, 1953, as the point in time that the United States "should have an air arm in being capable of dealing with a possible atomic attack," nominally referred to as A-day.[34] Phase one was the period from

[30] President's Air Policy Commission, *Survival in the Air Age* (Washington DC: Government Printing Office, 1948), 12, accessed November 21, 2015, https://archive.org/details/survivalinairage00unitrich.

[31] President's Air Policy Commission, *Survival in the Air Age*, 4.

[32] President's Air Policy Commission, *Survival in the Air Age*, 8.

[33] President's Air Policy Commission, *Survival in the Air Age*, 19.

[34] President's Air Policy Commission, *Survival in the Air Age*, 19.

publication of the report, January 1, 1948, until A-day, and phase two was post A-day. [35] Understanding the phase one and phase two military strategies provides a framework to understand the mindset of the period and resulting aircraft acquisition.

The Air Policy Commission assessed that the United States could not simply rely on nuclear weapons for a war occurring during phase one.[36] The stated priorities for phase one were an integrated military establishment that was; "(1) capable of an atomic attack, (2) stronger in air power than that of any other country, and (3) capable of a sustained and powerful air counteroffensive, either directly or by the way of intermediate bases."[37] The emphasis during phase one was logically offensive in nature, as this phase occurred prior to any credible threat to the United States. The concept of warfare was to maintain a nuclear-capable force centered on long and medium range bombers while ensuring air superiority. This strategy appeared sound during phase one, but omitted any defensive plans required for war during phase two.

The Commission recommended a gradual build-up of the forces required by A-day as the most cost effective means to procuring said force.[38] The phase two recommendations expounded on the defensive requirements to counter an adversary attack. The assumptions regarding an enemy attack included a direct assault on the US mainland using atomic weapons and arriving without warning.[39] Because of this, phase two requirements included development and fielding of "complicated defensive equipment of modern electronics and modern defensive fighter planes

[35] President's Air Policy Commission, *Survival in the Air Age*, 19.

[36] President's Air Policy Commission, *Survival in the Air Age*, 22.

[37] President's Air Policy Commission, *Survival in the Air Age*, 22.

[38] President's Air Policy Commission, *Survival in the Air Age*, 20.

[39] President's Air Policy Commission, *Survival in the Air Age*, 22-23.

and ground defensive weapons."[40] The report also called for a radar early warning system, but cautioned that "such a system, if designed to give complete and continuous coverage, would be extraordinarily expensive."[41] The commission feared too much expense directed toward defensive measures would deprive the United States of "the best defense against atomic attack, the counteroffensive striking force in being." [42] The report also called for "a counteroffensive force built around a fleet of bombers, accompanying planes, and long-range missiles which will serve notice on any nation which may think of attacking us that if it does, it will see its factories and cities destroyed and its war machine crushed."[43] This strategy fit Robert Pape's definition of deterrence, trying "to persuade a state not to initiate a specific action because the perceived benefits do not justify the estimated costs and risks."[44] The Air Policy Commission advocated deterrence through massive retaliation. In fact, the report stated, "The strength of the counteroffensive force must be such that it will be able to make an aggressor pay a devastating price for attacking us."[45] Whatever value existed in defensive capability, the commission clearly favored a deterrence strategy centered on a nuclear-based offensive bombing campaign. This conceptualization of warfare provided insight into the aircraft and armament in development after World War II and available to policy makers and military commanders entering the Korean War.

US policy vis-à-vis Korea was complicated in the years preceding the Korean War. In early 1949, Mao and the Chinese Communists won their fight in China, aligning the world's most

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[40] President's Air Policy Commission, *Survival in the Air Age*, 18.

[41] President's Air Policy Commission, *Survival in the Air Age*, 18.

[42] President's Air Policy Commission, *Survival in the Air Age*, 18.

[43] President's Air Policy Commission, *Survival in the Air Age*, 18.

[44] Robert A. Pape, *Bombing to Win: Air Power and Coercion in War* (Ithaca, NY: Cornell University Press, 1996), 12.

[45] President's Air Policy Commission, *Survival in the Air Age*, 18.

populous nation with the Soviet Union.[46] Later that year the USSR detonated its first atomic weapon, more than three years before A-Day, dramatically changing the global balance of power.[47] These events did not change the national security strategy. The military policy envisioned a strategic offensive in the West and a strategic defensive in the East.[48] A "Europe first" mindset dominated security strategy, even during the post-World War II era. The focal point for US policy in the East was Japan, and the main objective was denying the Soviets influence over Japan; therefore, denying them another industrialized nation to benefit from.[49] Further complicating any comprehensive strategy was the pressure on the US government to cut spending and move towards a balanced budget, accomplished mostly through reductions in defense spending.[50] Within this context, a broad Korean strategy was difficult to articulate.

The different components of the US government disputed the importance of Korea. "To the JCS [Joint Chiefs of Staff], the concept of security was not simply military but also political and psychological. Doubts about US power and will could erode informal alliances elsewhere and undermine trust," especially with the West European Allies.[51] President Truman worried about the credibility and survival of the UN if there was no response in Korea.[52] The War Department

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[46] Gary Donaldson, *America at War Since 1945: Politics and Diplomacy in Korea, Vietnam, and the Gulf War* (Westport, CN: Praeger, 1996), 11.

[47] Walter G. Moss, *A History of Russia Volume II: Since 1855* (New York: McGraw-Hill, 1997), 295.

[48] Michael James Lacey, ed., *The Truman Presidency*, rev. ed. (New York: Press Syndicate of the University of Cambridge, 1991), 399.

[49] Lacey, *The Truman Presidency*, 393.

[50] Donaldson, *America at War Since 1945*, 13.

[51] Lacey, *The Truman Presidency*, 414.

[52] Donaldson, *America at War Since 1945*, 17.

recognized Korea's political value, but minimized its military value, assuming any future war would be a general war against the Soviets.[53] Once the North Koreans' invasion began,

> Truman understood immediately the necessity of a limited response in Korea, that America could not become involved in an all-out war of the type it had fought so successfully in World War II. It was the right decision, and the Joint Chiefs supported him completely. However, he would be criticized severely for restraining American power, for not using all of the nation's resources in an effort to achieve total victory. But Truman realized the need for a limited war because of the possibility of Chinese and Soviet countermoves, and ultimately the outbreak of a third world war.[54]

It is under this context the United States entered into a limited war on the Korean peninsula. The Air Power Study was predicated on total war involving nuclear weapons. The research and development projects post World War II aimed to satisfy the concept of fighting total war. The platforms and weapons developed for total war against the Soviets shifted their employment towards a limited war in Korea.

Two key platform acquisition programs from this period helped fulfill the requirements provided by the commission; the F-86 Sabre, and the B-50 Superfortress. Only the F-86 was used in combat over Korea. The Air Policy Commission direction in 1948 provided justification to continue purchasing the B-50 Superfortress, essentially an upgraded version of the B-29, and reinforced the continued development of the F-86 Sabre, originally contracted for prototyping in 1945.[55] The B-50 fulfilled the doctrinal long-range nuclear bombing requirement, while the F-86 met the "requirement for a medium-range day fighter which could also be used for escort and dive bomber duties."[56] However, the requirement for a multi-use aircraft rather than a pure

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[53] Lacey, *The Truman Presidency*, 414.

[54] Donaldson, *America at War Since 1945*, 21.

[55] Maurice Allward, *F-86 Sabre* (New York: Charles Scribner's Sons, 1978), 14.

[56] Allward, *F-86 Sabre*, 14.

pursuit fighter reinforced the prewar focus on offensive operations outlined in the doctrine at the time.

The F-86 development approached survivability in a predictable fashion for its time. The designers focused on increasing both the speed and altitude performance characteristics compared to other aircraft. The F-86 set several speed records in both 1948 and 1953.[57] These performance characteristics were important in Korea. Aerial combat entered the jet age, but "the jet battles over Korea were relatively uncomplicated affairs. They were similar to those fought during World War II … There was no elaborate ground control, or self-seeking missiles."[58] Without surface to air missiles as a threat, there was no need for minimizing signature to ensure survivability. Speed was the critical factor, and the F–86 "more than matched the MiG-15 in performance."[59] It was a new platform with a revolutionary swept wing design. Regrettably, its armament did not receive the same attention as the aerodynamics.

The F-86 Sabre provided the overall performance necessary to compete with adversary aircraft, but its armament was lacking. The top of the line Sabre's employed six, half-inch M-3 Browning machineguns.[60] This configuration reveals a lack of development in weaponry. In fact, the configuration was standard for many American fighters during World War II, and "was not sufficient to ensure the destruction of a MiG-15."[61] The lack of forethought into armament created frustration for the crews piloting the aircraft. An Air Force commander in Korea reported,

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[57] Allward, *F-86 Sabre*, 24-25.

[58] Allward, *F-86 Sabre*, 32.

[59] US Air Force, History and Museums Program, *Within Limits: The U.S. Air Force and the Korean War*, by Wayne Thompson and Bernard C. Nalty (Washington, DC: Government Printing Office), 27, accessed December 1, 2015, http://www.afhso.af.mil/shared/media/document/AFD-101006-032.pdf.

[60] Allward, *F-86 Sabre*, 48.

[61] Allward, *F-86 Sabre*, 48.

"Of every three MiGs hit by his Sabres, two had escaped."[62] In this regard, the F-86 did not carry a sufficient payload to maximize their tactical mission success. Insufficient weaponry compromised the required effect of gaining air superiority.

The original requirement for the F-86 specified the need for a fighter-bomber, adding flexibility to its mission capabilities. Early versions of the F-86 lacked this capability, and the first use of the F-86 Sabre as a fighter-bomber was the introduction of the F-86F in early 1953.[63] Because the F-86 was the only viable option to combat the MiG-15s patrolling in Norther Korea, the bombing mission became secondary. As such, the fighter-bomber units were the last to receive the F-86, and its impact as a bombing platform was minimal.

Despite its shortcomings, the F-86 proved effective in the greater context of the Korean War. Political constraints called for military leadership to fight a limited war. Given the limitations, air superiority was paramount to prevent escalation. Unfortunately for American forces, the Soviet-built MiG-15 outperformed the other aircraft available in terms of speed and maneuverability.[64] The F-86 was the only counter the American forces had to the MiG-15. General William Momyer reflected in hindsight:

> It gets back to the performance of aircraft, the importance of air superiority is that to be able to survive in the environment the weapon system must be tailored so that it can fight in the environment. The Navy asked to be withdrawn from patrols along the Yalu [River on the Chinese border] because the performance of their aircraft was such they couldn't compete with the Mig-15 and the Mig-17. It had to be handled by the F-86s.[65]

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[62] Allward, *F-86 Sabre*, 48.

[63] US Air Force, History and Museums Program, *MiG Alley: The Fight for Air Superiority*, The United States Air Force in Korea Series, by William T. Y'Blood (Washington, DC: Government Printing Office), 34, accessed December 1, 2015, http://www.afhso.af.mil/shared/ media/document/AFD-100928-020.pdf.

[64] Thompson and Nalty, *Within Limits*, 27.

[65] US Air Force, Office of Air Force History, *Air Superiority in World War II and Korea*, by James Ferguson, Robert M. Lee, William Momyer, and Elwood R. Quesada, interview with Richard H. Kohn, ed. Richard H. Kohn and Joseph P. Harahan (Washington, DC: Government

Without the F-86, US forces risked losing air superiority, and policy makers risked losing the war, or needing to escalate to defeat North Korea and its allies. Other platform enhancements were not as successful.

The sheer number of enemy fighters affected the air interdiction campaign by forcing changes to bombing tactics. In October of 1951, MiGs shot down five B-29s in a single week, forcing bomber command to attack exclusively at night.[66] The bombers "turned to the short-range navigation (SHORAN) electronic beam system, a network of ground-based radar beacons," which allowed bombing at night and in bad weather.[67] Essentially the SHORAN system reduced the bomber's signature, making them more "stealthy," by enabling them to accomplish their mission at night. This platform capability increased survivability because night intercepts were difficult to execute due to the enemy lacking radar capability. The system proved flexible, eventually expanding to tactical aircraft providing close air support, and providing support to ground forces in weather that was otherwise prohibitive.[68]

SHORAN did not solve all of the bombing problems in Korea. One key requirement to the method was extremely accurate maps.[69] Because the maps of Korea were lacking in overall accuracy, and detailed imagery was difficult to acquire due to North Korean air defenses, the

Printing Office, 1983), 81, accessed November 22, 2015, http://www.afhso.af.mil/ shared/media/ document/AFD-100525-068.pdf.

[66] Thompson and Nalty, *Within Limits*, 41.

[67] Thompson and Nalty, *Within Limits*, 41.

[68] US Air Force, History and Museums Program, "Air Power Coordination during the Korean War," by Jerry Miller, in *Coalition Air Warfare in the Korean War: 1950-1953*, edited by Jacob Neufield and George M. Watson, Jr. (Washington, DC: Government Printing Office, 2005), 180, accessed November 21, 2015, http://www.afhso.af.mil/shared/media/document/AFD-100924-016.pdf.

[69] Miller, "Air Power Coordination," 180.

circular error of probability for the SHORAN missions was 1,220 feet.[70] While this error was sufficient for large area targets such as airfields or industrial complexes, it was not sufficient for smaller facilities or close air support. Using SHORAN to deliver munitions required detailed intelligence prior to mission execution. The poor imagery mandated that daytime bombing missions continue in order to meet operational requirements. While SHORAN attempted to increase the survivability of the older bombers, there was a weapons program with the goal of increasing weapon lethality.

Logistics present a vital requirement for any army in a protracted war, making interdiction of supplies and routes a key operational objective for any air force. General George Stratemeyer directed such a campaign in January 1951.[71] An important target to the overall campaign were the myriad of road and rail bridges throughout North Korea. Unfortunately, the fighter-bombers were not very effective in this mission due to their limited payloads.[72] Because of this, the mission went to the less survivable B-29s who had to fly at higher altitudes to avoid air defenses, decreasing their accuracy.[73] To make up for the decreased accuracy, three to four bombers were used for each bridge.[74] Radio controlled bombs offered a more efficient means. Tarzon was a 12,000-pound bomb, which used a similar guidance system to the 1,000 pound Razon bomb dating back to World War II.[75] Tarzon's yield was sufficient to destroy one or two

[70] US Air Force, Office of Air Force History, *The United States Air Force in Korea 1950-1953*, by Robert F. Futrell, rev. ed. (1991; repr., Washington, DC: Government Printing Office, 1996), 417, accessed December 3, 2015, http://www.afhso.af.mil/shared/media/document/AFD-101202-022.pdf.

[71] Futrell, *The United States Air Force in Korea*, 313.

[72] Futrell, *The United States Air Force in Korea*, 318.

[73] Futrell, *The United States Air Force in Korea*, 318.

[74] Futrell, *The United States Air Force in Korea*, 319-320.

[75] Futrell, *The United States Air Force in Korea*, 320.

bridge spans with a single bomb, rather than the requirement to hit a single span with several 1,000 pound bombs. The accuracy, however, was suspect. In thirty uses, Tarzon bombs accounted for six bridges destroyed, and one damaged; versus nineteen misses, and three duds.[76] The program was discontinued after a safety anomaly prevented a safe jettison of the weapon and potential to cause the loss of a B-29.[77] Ultimately, the Tarzon bomb met the yield requirement for its objectives. The overall lack of precision combined with the survivability issues were reasons enough to cancel its use. The bomb did not meet the operational requirements of the battlefield.

Overall, the post-World War II period's weapon development was remarkable for its lack of progress. The focus on total war prevented development of weapons for a limited war. There were minor attempts to rectify deficiencies, such as the undersized browning machine-guns on the F-86 under project 'Gun-Val'.[78] There were attempts to fit larger caliber guns on the F-86 to increase its effectiveness against the MiG-15. The new 20mm weapons proved reliable and showed promise for future fighters, but there were two problems making it unsuitable for combat on the F-86 at the time; the new weapon had a short firing time, and created a compressor stall on the F-86, making it unsuitable for combat.[79] Platform limitations prevented modification of weaponry that would increase the effectiveness of the F-86. There was not enough surplus capability in the design of the platform to accommodate changes in the weaponry.

The USAF entered the Korean War with a concept of operations based on offensive bombing with nuclear weapons in order to accomplish its mission. The national policy for the

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[76] Futrell, *The United States Air Force in Korea*, 322-323.

[77] Futrell, *The United States Air Force in Korea*, 322.

[78] Allward, *F-86 Sabre*, 49.

[79] George Stratemeyer to Nathan Twining, December 25, 1950, in US Air Force, History and Museums Program, *The Three Wars of Lt. Gen. George E. Stratemeyer: His Korean War Diary*, ed. William T. Y'Blood (Washington, DC: Government Printing Office, 1999), 33, accessed December 3, 2015, http://www.afhso.af.mil/shared/ media/document/AFD-101001-048.pdf.

Korean War was one of containment with limited aims. The service found itself fighting a conventional conflict with a force structure designed around nuclear war. The B-50 under design had no impact on the conflict. The F-86 Sabre achieved its objective of gaining air parity, and in some cases superiority. This was accomplished against an enemy with more mass, due to the F-86 survivability. The Sabre was at a disadvantage due to the lack of weapons development. A larger gun proved beneficial in testing, but the platform did not have the excess capacity to adapt to the new weapon. The SHORAN system proved useful in increasing bomber survivability, but ultimately did not have the intelligence support required for effectiveness. The Tarzon bomb proved a failure and limited the efficacy of the bombing force's interdiction mission. Due to a complete mismatch between the concept of warfare and the nature of the actual fighting, weapon development failed to affect the Korean War. In this case, platform development proved most effective.

Steady Course, More Surprises: The Vietnam War

The conclusion of the Korean War offered the United States the opportunity to reassess its national defense strategy and reframe its acquisition and budgeting priorities. "Perhaps the paramount question of the time was whether we should prepare to fight limited as well as general wars."[80] During the immediate aftermath of the Korean War, President Eisenhower, and his Secretary of State, John Dulles, kept it in their minds and believed "the lesson that intervention in a limited war was largely unwinnable."[81] There was a strong contingent amongst US policymakers who believed that, "we would never fight, nor should we prepare to fight another Korea. Once again nuclear forces were accepted as the dominant element of our national security,

[80] William W. Momyer, *Airpower in Three Wars*, ed. A. J. C. Lavalle and James C. Gaston (1978; repr., Maxwell Air Force Base, AL: Air University Press, 2003), 6.

[81] Donaldson, *America at War Since 1945*, 84.

and all [military] forces were evaluated in light of their usefulness in the event of nuclear conflict."[82] The nuclear deterrence strategy also fit well with President Eisenhower's *New Look* foreign policy.

The *New Look* strategy defined US defense policy after the Korean War, but was similar to the policies in place prior to the war. The major goal of the *New Look* policy was to rely on "massive retaliation" to threaten the Soviets and achieve foreign policy goals, while simultaneously curtailing defense spending.[83] "Eisenhower had little stomach for joining a losing cause in the jungles of Southeast Asia."[84]There was one major change compared to the post World War II era, the Soviet nuclear threat. The Soviets' possession of the atomic bomb returned the USAF to the "rulebook and principles of war," acknowledging that the first priority was to gain air superiority.[85] General Thomas White, the Air Force Chief of Staff, "asserted that hostile air forces would always be the primary concern and priority target of the total US air forces" under the *New Look* doctrine.[86] "As a second priority to the counterair strikes, the Strategic Air Command (SAC) planned to support theater commanders in retarding the advance of Soviet ground forces."[87] The Air Force view of warfare was nuclear deterrence first, followed by a counterforce strategy prioritizing the objective of gaining air superiority and interdiction of

[82] Momyer, *Airpower in Three Wars*, 6.

[83] Donaldson, *America at War Since 1945*, 91.

[84] Donaldson, *America at War Since 1945*, 82.

[85] Robert Frank Futrell, *Ideas, Concepts, Doctrine, Vol. 1, Basic Thinking in the United States Air Force, 1907-1960*, rev. ed. (Maxwell Air Force Base, AL: Air University Press, 1989), 433.

[86] Futrell, *Ideas, Concepts, Doctrine, Vol. 1*, 433.

[87] Futrell, *Ideas, Concepts, Doctrine, Vol. 1*, 436.

enemy forces. The USAF continued to innovate missions for its tactical forces as well as the strategic bombers.

A minority existed within the Air Force that believed limited wars would resurface. Within the new security strategy, Tactical Air Command (TAC) saw its mission as delivering the nuclear weapons needed to defeat the Soviet army in the field. To prepare and train for this mission, "the Air Force permitted the Tactical Air Command to activate the Nineteenth Air Force as an operational headquarters … on 8 July 1955," establishing the Composite Air Strike Force.[88] With this new mission, TAC's nuclear strike and aerial-refueling capability allowed tactical air forces to provide an effective deterrent in limited wars.[89] Because of the *New Look* doctrine, the counter to limited wars was a tactical nuclear deterrence delivered by TAC. The focus on nuclear weapons meant the USAF did not revert to an emphasis on gaining air superiority, but instead focused all of its platforms on nuclear weapon delivery.

In 1961 the Kennedy administration took over in Washington, DC, and began reassessing the defense doctrine. After examining the *New Look* policy, "it had become evident to the new Kennedy administration that such a plan left the United States vulnerable in its conventional warfare capabilities, unable to put out the inevitable *brushfires* of Communist insurgencies throughout the world."[90] In response to Nikita Khruschchev's speech declaring wars of liberation as the future, President Kennedy directed immediate development of US forces focused on sub-limited wars.[91] General William Momyer recalled that,

> This reorientation of our defense priorities toward smaller conflicts prompted considerable debate about how best to cope with these wars … In the Air Force, many believed that existing tactical forces could adjust to counterinsurgency warfare without

[88] Futrell, *Ideas, Concepts, Doctrine, Vol. 1*, 450.

[89] Futrell, *Ideas, Concepts, Doctrine, Vol. 1*, 450.

[90] Donaldson, *America at War Since 1945*, 91.

[91] Momyer, *Airpower in Three Wars*, 9.

> major change, while others argued that counterinsurgency was the combat of the future and that the Air Force should build a special force for such conflicts.[92]

Again, the tension between strategic bombing and nuclear deterrence versus conventional and low-density conflict emerged. Rather than prepare for so-called *sub-limited* wars, the Air Force continued procuring equipment designed for nuclear deterrence, and assumed that the force was flexible enough to adapt. The Vietnam War would provide the testbed for their theory.

The Korean War heavily influenced the nature of the US involvement in Vietnam. The "National Security Council directives that mapped US foreign policy in Asia made it clear that the US government believed strongly that communism, directed from Moscow, was attempting to spread throughout Asia, and that it was the mission of the United States to stop that spread through military means if necessary."[93] Gary Donaldson provides the political landscape entering the Vietnam War:

> The United States became involved in both wars for many of the same reasons, but most importantly to maintain its role as a world leader, to show the Third World that the United States was the one nation willing and able to stand up to communism anywhere in the world — even in the hostile jungles and rice paddies of Vietnam. Along with that came the commitment to containment, to halt the expansion of communism, and to stop Communist aggressions. At the same time, like Korea, Vietnam had little strategic value for U.S. foreign policy, military planning, or strategy in Asia.[94]

The experience of Korea, and the Chinese involvement therein, influenced US policy fifteen years later in Vietnam, especially as it related to attacks into North Vietnam.[95] In 1962, "relatively few senior DOD officials thought seriously about a strategic air offensive against North Vietnam."[96] The policy of escalation in Vietnam continued, and on February 8, 1965, the

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[92] Momyer, *Airpower in Three Wars*, 9.

[93] Donaldson, *America at War Since 1945*, 64.

[94] Donaldson, *America at War Since 1945*, 70.

[95] Donaldson, *America at War Since 1945*, 63.

[96] Momyer, *Airpower in Three Wars*, 12.

Air Force flew the first strikes of Operation Rolling Thunder.[97] The USAF once again found itself engaged in a limited war in Asia with platforms and weapons designed for nuclear deterrence.

Three of the USAF platform acquisitions leading up to the Vietnam War stood out; the F-105 Thunderchief, the B-52 Stratofortress, and the F-4 Phantom. One commonality across all three platforms is that the mission assigned to each varied from that imagined in the prewar period.

The F-105 Thuderchief was exactly what TAC needed to deliver tactical nuclear weapons against Soviet fielded forces. Unfortunately for the USAF, Vietnam was not the war the platform was designed for. The F-105 was "designed around a bomb bay that could accommodate a nuclear weapon."[98] While it was a technologically superior aircraft, the plane was designed and built "for high speed, low-level delivery of [nuclear] weapons."[99] The aircraft was a bomber first, and its survivability characteristics reflected that priority. The aircraft was fast, fifty percent faster than the F-100D it replaced in TAC.[100] The F-105 relied on speed to avoid airborne interceptors, and used low-level capability to evade detection by enemy air defenses. Due to its primary design as a bomber, the Thunderchief displayed an "inability to turn effectively during air-to-air engagements."[101] In such situations, the pilots "learned to depend instead upon the F-105's great speed to outrun MIGs which attacked while inbound to target and to use that speed to chase MIGs

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[97] US Air Force, History and Museums Program, *Gradual Failure: The Air War Over North Vietnam 1965-1966*, The United States Air Force in Southeast Asia: 1961-1973 Series, by Jacob Van Staaveren (Washington, DC: Government Printing Office, 2002), 84, accessed December 11, 2015, http://www.afhso.af.mil/shared/media/document/AFD-100526-034.pdf.

[98] Kenneth P. Werrell, *Chasing the Silver Bullet: U.S. Air Force Weapons Development from Vietnam to Desert Storm* (Washington, DC: Smithsonian Books, 2003), 11.

[99] Delbert Corum et al., "The Tale of Two Bridges," ed. Dewey Waddell and Norm Wood, in *Air War-Vietnam*, ed. Drew Middleton, (New York: Arno Press, 1978), 12.

[100] Werrell, *Chasing the Silver Bullet*, 11.

[101] Corum et al., "The Tale of Two Bridges," 16.

after bomb delivery."[102] Unfortunately, speed alone did not make for a good air superiority platform. "The F-105 had the highest loss rate of any United States aircraft operating in Southeast Asia."[103] The bomber focus, called for by the USAF's view of warfare at the time, limited its survivability in an air-to-air role.

The flexibility of the F-105 demonstrated a limitation in an air superiority role, but created opportunities to accomplish policy makers' objectives. One increase to the Thunderchief's flexibility was "in response to Secretary of Defense Robert McNamara's early 1961 call for more nonnuclear capability, the USAF modified the F-105 by adding pylons to carry external stores."[104] TAC's nuclear fighter-bomber was equipped to fight a limited war in Southeast Asia. Despite its relatively poor record in aerial combat, the F-105 conducted most of the difficult work in the early years of the Vietnam War. The aircraft flew three-quarters of the strike missions during Operation Rolling Thunder at the beginning of the war.[105] The aircraft was the primary platform used to conduct bombing missions in the northern portion of the battlefield. The heavy workload was due in part to its large payload.

The bomber-focused design of the F-105 showed in its payload. It was capable of carrying twice the bombload of the F-100D it replaced, and it also mounted a rapid-firing 20 mm Gatling gun; its air-to-air role was secondary.[106] However, the accuracy of the weapon delivery system was a limitation. "The radar bombing system fitted to the F-105 was designed to deliver a

[102] Corum et al., "The Tale of Two Bridges," 16.

[103] Werrell, *Chasing the Silver Bullet*, 13.

[104] Werrell, *Chasing the Silver Bullet*, 13.

[105] Werrell, *Chasing the Silver Bullet*, 13.

[106] Werrell, *Chasing the Silver Bullet*, 11.

nuclear weapon against an area target, for which a miss by 1,500 to 2,000 ft was acceptable."[107] These miss distances were not conducive to the Vietnam War objectives of striking point targets such as bridges and roads with conventional weapons. The limitations of the F-105 targeting system created problems for targeteers and affected bombing strategy. Often a target choice for F-105 strikes was "selected more for its topographical features and distinctive radar signature than for any intrinsic military importance."[108] Rather than choosing targets based on strategy or policy, the technology available limited the planners to a subset of targets that fit the requirements of the platform. In some cases, these sets of targets overlapped, but in other situations, the technology limited policy maker's options.

While the F-105 spent its time striking targets in the North, SAC's B-52 was conducting close air support in the South. The initial operating concept for the B-52 Stratofortress was a long-range platform to deliver atomic bombs at the start of hostilities from the continental United States.[109] "The original Boeing XB-52 contract [was] awarded in July 1948," predating even the Korean War.[110] The aircraft missed the Korean War, becoming operational in 1955, but was SAC's frontline bomber and was the delivery mechanism for America's nuclear arsenal.[111] The employment of the B-52 suffered from political constraints throughout the Vietnam War. Even as late as May 1972, "B-52 strikes required approval of the target by the Secretary of Defense 24 hours in advance of proposed time over target," unless the targets were in the southernmost part

[107] Benjamin S. Lambeth, *The Transformation of American Air Power* (Ithaca, NY: Cornell University Press, 2000), 34-35.

[108] Lambeth, *The Transformation of American Air Power*, 35.

[109] Mark D. Mandeles, *The Development of the B-52 and Jet Propulsion: A Case Study in Organizational Innovation* (Maxwell Air Force Base, AL: Air University Press, 1998), 62.

[110] Norman Polmar, ed., *Strategic Air Command: People, Aircraft, and Missiles* (Annapolis, MD: Nautical and Aviation Publishing Company of America, 1979), 165.

[111] Polmar, *Strategic Air Command*, 166.

of North Vietnam.[112] The constraint illuminates the impact policy makers had on how the military was allowed to conduct the war.

The B-52 design focus centered on surviving just long enough to get its nuclear payload to the target area. The original concepts concluded that, "the aircraft's mission should be 'special operations and not sustained operations, and therefore the advantage of surprise would permit the installation of tail armament only instead of all-around armament."[113] Of course, this concept did not originally include flying into heavily defended airspace. The B-52 lacked all of the survivability metrics considered under the methodology here. The aircraft was extremely large, and not overly fast. Because of its size and restricted maneuverability, it was "a lucrative target for both MIG interceptors and SAMs, and thus required a great deal of protection."[114] The limited survivability affected the flexibility of the platform and the options available to planners.

The B-52 was the frontline USAF bomber during the Vietnam War, but its use was limited. The lack of survivability initially restricted the use of the platform to targets in safer areas in the south. Melyan and Bonetti highlight the impact of low survivability below:

> U.S. successes in avoiding SAM's was due almost entirely to the rapid evasive action taken by the highly maneuverable tactical aircraft after [electronic intelligence] ELINT warning or the visual observation of the SAM. He [CINPAC] stated that the B-52's, of course, were not capable of making such a violent maneuver and … in consideration of the limited return that could be expected from this attack and the risks involved, he believed that the use of B-52's should not be authorized, and added that JCS also disapproved.[115]

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[112] US Air Force, Headquarters Pacific Air Forces, Contemporary Historical Examination of Current Operations Division, *Linebacker Operations: September – December 1972*, by Melvin F. Porter (Washington, DC: Government Printing Office, 1978), 4.

[113] Mandeles, *The Development of the B-52*, 110.

[114] Paul Burbage et al., "The Battle for the Skies over North Vietnam," ed. Gordon Nelson and Norm Wood, in *Air War-Vietnam*, edited by Drew Middleton (New York: Arno Press, 1978), 278.

[115] US Air Force, Headquarters Pacific Air Forces, Contemporary Historical Examination of Current Operations Division, *Rolling Thunder: July 1965 – December 1966*, by Wesley R. C. Melyan and Lee Bonetti (Washington, DC: Government Printing Office, 1967), 104.

The limitations restricted the use of the bomber for its prescribed mission of strategic attack. Given the restriction on using the B-52 in the northern portions of Vietnam, planners had to take a new approach.

Military planners considered how to use the platform in the southern portion of the theater. “One of the major innovations of the air war in South Vietnam was the extensive use of B-52 bombers in the close support of ground forces.”[116] The B-52 flexed to the new missions, referred to as Arc Light. Most of the Arc Light missions were directed using ground radar systems “yielding high accuracy and allowing last-minute changes in targets.”[117] These last-minute changes allowed for increased flexibility on a dynamic battlefield, which was especially important when bombing enemy fielded forces. In cases where the ground radar was not available, “the highly accurate, self-contained radar bombing system of the B-52 was occasionally used to bomb primary targets and a majority of the secondary targets.”[118] Survivability was a liability for the B-52, but it proved flexible enough to contribute to the bombing campaign in the southern portion of North Vietnam. Military planners had not previously considered using the platform for close air support, but adapted when the threat limited its use in a traditional role. The massive payload also proved valuable.

The B-52’s payload was far larger than any other bomber in the theater. “Eighty-two of them had been modified in 1965 to carry eighty-four 500 lb bombs on wing pylons, a total

[116] Corum et al., “The Tale of Two Bridges,” 94.

[117] John A. Doglione et al., “Airpower and the 1972 Spring Invasion,” ed. by Donaldson D. Frizzell and Ray L. Bowers, in *Air War-Vietnam*, edited by Drew Middleton (New York: Arno Press, 1978), 111.

[118] US Air Force, Headquarters Pacific Air Forces, Contemporary Historical Examination of Current Operations Division, *The Air War in Vietnam: 1968 - 1969*, by K. Sams et al. (Washington, DC: Government Printing Office, 1970), 60.

bombload of 60,000 lb, or about the equivalent of five fighter-bombers."[119] This was a massive amount of firepower. During the war, B-52s typically employed as a cell of three and produced "devastating physical and psychological effects on enemy units."[120] While battle damage assessment was difficult to attain, "the psychological impact was immense. Enemy prisoners indicated the "airstrikes forced them to move constantly, kept them off balance, caused numerous casualties, lowered morale, and prevented them from staging significant offensive action."[121] There was also evidence that the "B-52 strikes continually frustrated the enemy's ground attacks by inflicting heavy casualties on troop concentrations," preventing the enemy from massing forces for attacks.[122] The sheer number of bombs delivered in one strike forced the enemy to change tactics, and limited their ability to mass forces for offensives. The B-52s continued bombing in the southern portion of the conflict zone, even while a new fighter-bomber arrived in theater.

By 1972, the newer F-4 Phantom had replaced most of the F-105s in the Vietnam theater of operations.[123] The US Navy designed the Phantom as an "all weather, high-altitude" interceptor for fleet defense.[124] The aircraft relied on speed and long range missiles for survivability. During the late 1950's and early 1960's, the F-4 set 15 speed records.[125] This was its primary advantage against the newest Soviet plane, the MiG-21. "Only in range and first-shot

[119] Corum et al., "The Tale of Two Bridges," 95.

[120] Doglione et al., "Airpower and the 1972 Spring Invasion," 111.

[121] K. Sams et al., *The Air War in Vietnam: 1968 - 1969*, 66-67.

[122] John W. Vogt, quoted in Doglione et al., "Airpower and the 1972 Spring Invasion," 150.

[123] Corum et al., "The Tale of Two Bridges," 16.

[124] Corum et al., "The Tale of Two Bridges," 21.

[125] Werrell, *Chasing the Silver Bullet*, 43.

capability does the F-4C enjoy a substantial advantage over the MiG-21 throughout the envelope."[126] Additionally, the aircraft did not minimize its signature to increase survivability. The Phantom had a large silhouette and created a heavy black smoke trail when airborne, making visual identification, and tracking easy.[127] Despite these setbacks, the F-4 proved capable in all of its mission sets over Vietnam.

As the replacement for the F-105, the F-4 had to assume all of the missions of the F-105. By the end of the Vietnam War, the Phantom could perform "air superiority, close air support, interdiction, air defense, and long range bombardment with devastating effectiveness."[128] The platform "proved to be the most versatile combat aircraft employed during the Southeast Asia conflict."[129] The airframe designed as an interceptor was extremely capable as a multi-role fighter, and able to adapt to the myriad of munitions developed throughout the war to confront the significant targeting constraints stemming from national policy.

The F-4 had an impressive payload and was capable of carrying most of the munitions used in the Vietnam War. One of the major handicaps was the lack of a gun or cannon. "The F-4's original mission of intercepting standoff threats to Navy carriers with long-range missiles occasioned it to be designed without an internal cannon."[130] The concept was that in an air-to-air engagement at sea, the F-4 would not need to dogfight, but would shoot down enemy aircraft with missiles from beyond visual range. This assumption proved false in the skies over Vietnam, and "some F-4s were fitted with SUU-16 20-mm cannon pods mounted on the aircraft's centerline

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[126] Lambeth, *The Transformation of American Air Power*, 42.

[127] Serge Herzog, *Defense Reform and Technology: Tactical Aircraft* (Westport, CT: Praeger, 1994), 22.

[128] Corum et al., "The Tale of Two Bridges," 21.

[129] Corum et al., "The Tale of Two Bridges," 21.

[130] Lambeth, *The Transformation of American Air Power*, 42.

station. That development offered only a temporary fix, however, because of the increased fuel consumption and decreased maneuverability caused by the gun pod's high aerodynamic drag."[131] By late 1971, the F-4E was delivered with an internal gun to mitigate setbacks in the air superiority mission. The platforms used over Vietnam benefited from weapons development throughout the war.

The emphasis on weapon development between the Korean War and the Vietnam War aligned with the "massive retaliation" concept of the *New Look* doctrine. The overarching focus was on nuclear weapon development, especially in the USAF. In the early 1960's, the effort shifted towards more conventional weapons with President Kennedy's *Flexible Response* policy. As the conflict in Vietnam grew, so too did the emphasis on conventional weapons. Urgent requirements and increased resources "played a noticeable role beginning early in the Vietnam conflict. By early 1965, the Air Force chief of air materiel acquisition had already established a special limited war office … dedicated specifically to the acquisition of technology that promised immediate improvements to air combat in Vietnam"[132] The advances in conventional weapons technology were a result of the war rather than preparation for war.

At the outset of the war, air planners had few options available to execute the limited war they were planning. With nuclear weapons off the table, the largest yield available in appreciable numbers at the beginning of Operation Rolling Thunder were 750 lb general-purpose bombs.[133] The fighter-bombers that focused training on their nuclear mission had to use 750 lb bombs to hit point targets rather than the area targets they trained for. The story of the Thanh Hoa Bridge epitomizes the American munitions development before, and during the Vietnam War. The first

[131] Lambeth, *The Transformation of American Air Power*, 42.

[132] Gillespie, *Weapons of Choice*, 76.

[133] Corum et al., "The Tale of Two Bridges," 42.

attack on the bridge was on April 2, 1965, using "ten dozen 750-pound, general purpose bombs and thirty-two missiles" on the bridge, but it "gave no evidence of going down."[134] "Seven years and 869 sorties later, traffic was still crossing Thanh Hoa unimpeded."[135] Weapons development continued striving for answers throughout the Vietnam War.

The Vietnam War welcomed the era of operable precision munitions. The United States pursued two different weapons programs, Paveway I and Paveway II, focused on laser guidance and contrast television seekers, respectively.[136] The Paveway I program developed a laser modification for both the Mark-84 2,000 pound bomb, and the Mark-117 750 pound bomb.[137] These bombs were chosen for modification because they were already in stock, and in the case of the Mark-84, had already proved reliable, rugged, and capable of producing great cratering, blast, and fragmentation effects.[138] The Mark-84 met the yield requirement to achieve objectives, provided the bomb hit its desired target.

The intention of the Paveway I program was increased precision of conventional weapons for employment in a limited war. The objective circular error probable (CEP) for the program was forty feet.[139] In nonprofessionals' terms, a CEP of forty feet equates to half of the weapons

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[134] Corum et al., "The Tale of Two Bridges," 37.

[135] Gillespie, *Weapons of Choice*, 76.

[136] US Air Force, Headquarters Pacific Air Forces, Contemporary Historical Examination of Current Operations Division, *Second Generation Weaponry in Southeast Asia*, by Melvin F. Porter (Washington, DC: Government Printing Office, 1970), 18, 49.

[137] Porter, *Second Generation Weaponry*, 18.

[138] Porter, *Second Generation Weaponry*, 19.

[139] Porter, *Second Generation Weaponry*, 18.

striking within forty feet of the designated target.[140] Testing in Vietnam revealed a CEP of forty-five feet for the Mark-117 bombs, and a CEP of twenty feet for the Mark-84 munitions.[141] Ultimately, the Paveway I program moved entirely to Mark-84 weapons. "The rationale boiled down to this: if a target was worth assigning a guided bomb—with its expensive seeker head, guidance and control equipment—then cost effectiveness alone dictated that it be mated to a heavier, all-purpose and more accurate bomb."[142] The weapon proved successful. During a six-month period in 1969, "the average miss distance was seventeen feet; the CEP remained at zero."[143] The main detriment was the requirement for pilots to keep the laser pointed at the target until impact of the weapon. The requirement forced pilots to stay within the target area and increased their exposure to enemy air defenses. The desired improvement was a *launch and leave* capability, or ability to release the weapon and immediately leave the target area, to increase aircraft survivability.

The Paveway II program was designed to provide *launch and leave* capability based on a contrast seeker.[144] The electro optical seeker was mated with a Mark-84 bomb, similar to the Paveway I.[145] The program ultimately proved successful, with testing revealing a CEP of zero feet.[146] The USAF had two precision munitions, one of which provided a *launch and leave*

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[140] William Nelson, *Use of Circular Error Probability in Target Detection* (Bedford, MA: The MITRE Corporation, 1988), 1, accessed March 16, 2016, http://www.dtic.mil/dtic/tr/fulltext/u2/a199190.pdf.

[141] Porter, *Second Generation Weaponry*, 21.

[142] Porter, *Second Generation Weaponry*, 23.

[143] Porter, *Second Generation Weaponry*, 30.

[144] Porter, *Second Generation Weaponry*, 49.

[145] Porter, *Second Generation Weaponry*, 50.

[146] Porter, *Second Generation Weaponry*, 53.

capability. These bombs ultimately opened the target selection aperture by decreasing the collateral damage of bombing missions. One such example is a mission that successfully destroyed a North Vietnamese hydroelectric plant while leaving the dam, which was only fifty feet away, undamaged.[147] Such targets were untenable before the introduction of precise munitions. Policy decision regarding targets were far less constrained by weapons effects.

The Paveway weapons were not a panacea that solved all of the problems in air-to-ground combat. Similar to previous weapons advancement, the Paveway program created demands on the staffs responsible for mission preparation. Successful Paveway "strikes demanded painstaking preparation … and a detailed prestrike briefing of the aircrew involved. Terrain features, cultural areas, target dimensions, target construction, and the similarity of nearby features to targets were but a few of the things that had to be known and understood thoroughly."[148] These weapons required a dramatic increase in intelligence requirements compared to previous conflicts. Weather also played a vital role for the precision bombs. "Guided bombs were not all-weather weapon systems. Clouds and haze were the largest inhibiting factors preventing the optimum exploitation of guided weaponry in the tactical environment. Pilots had to see and identify targets before hitting them successfully."[149] Camouflaged targets also proved more difficult to hit, especially for the contrast seeker on the Paveway I munitions. "This resulted in both decreased accuracy and increased [time on target] TOT. Consequently, [laser guided bombs] LGBs were employed over heavily defended targets in the northern one-half of North Vietnam, almost to the exclusion of [electro-optical guided bombs] EOGBs, which were largely

[147] Lambeth, *The Transformation of American Air Power*, 40.

[148] US Air Force, Headquarters Pacific Air Forces, Contemporary Historical Examination of Current Operations Division, *Guided Bomb Operations in Southeast Asia: The Weather Dimension, 1 February – 31 December 1972*, by Patrick J. Breitling (Washington, DC: Government Printing Office, 1973), 16.

[149] Breitling, *Guided Bomb Operations*, 34.

limited to use over the more lightly defended targets" in the south.[150] Unfortunately, the weapon with the most standoff potential also had the most difficulty in adverse weather.

While there were challenges, the Paveway programs proved successful. Before turning to the fight for aerial dominance, one must revisit the battle of the Thanh Hoa Bridge. "On May 13, 1972, twelve F-4s armed with laser guided bombs attacked the infamous Thanh Hoa Bridge … Often called 'the toughest interdiction target of them all.'"[151] The twelve F-4s and their twenty-four laser guided bombs "rendered Thanh Hoa completely unusable, accomplishing in a single mission what seven years of nonprecision [sic] bombing had failed to do."[152] New weaponry enabled the destruction of a key bridge that the North Vietnamese used to supply their forces. Unfortunately the fight for air supremacy did not realize the same success.

While TAC prepared for its doctrinal mission using tactical nuclear weapons, the US Navy took the lead in developing the weapons necessary for airborne interceptors. "All of the U.S. air-to-air missiles employed in Vietnam had been designed in the first place not to engage hard-maneuvering fighters, but rather to shoot down nonmanuevering [sic] bombers at high altitudes.[153] Sparrow I was the Navy's first operational air-to-air missile, coming into service in 1956. Ultimately, the Sparrow III, designated the AIM-7C/D/E, replaced the Sparrow I, and was the centerpiece for the design of the F-4 Phantom.[154] The AIM-7C carried a 65 lb Mark-38

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[150] Breitling, *Guided Bomb Operations*, 20.

[151] Gillespie, *Weapons of Choice*, 116.

[152] Gillespie, *Weapons of Choice*, 116.

[153] Lambeth, *The Transformation of American Air Power*, 43.

[154] Ron Westrum, *Sidewinder: Creative Missile Development at China Lake* (Annapolis, MD: Naval Institute Press, 1999), 45-46.

continuous rod warhead.[155] The overall yield of the weapon proved deadly, as long as the missile guided on its target.[156]

The AIM-7 did not deliver the precision expected during the Vietnam War. From the beginning of 1965, until March 1968, the Air Force fired 224 AIM-7s for twenty kills resulting in an 8.9 percent success.[157] One reason was the aforementioned reality of fighting against maneuvering fighters rather than large bomber aircraft the missile was designed for. The advantage to the AIM-7 was its range. The AIM-7 "could be fired from any aspect, not just behind the target" and "had a longer range than either the guns or the [infrared] IR missiles."[158] Unfortunately, the environment the Sparrow was designed for, clear points of origin and missiles fired at a large stand-off distance, did not match the reality of Vietnam. The identification friend or foe [IFF] system, an electronic means to identify friendly aircraft, was not reliable.[159] Without a means to identify friendly aircraft, the risk of fratricide was high. "The fear of downing friendly aircraft forced American pilots to obtain positive identification before launching missiles, largely negating the American advantages of longer missiles and airborne radar range."[160] "U.S. airmen apparently registered only two beyond visual range (BVR) kills during the entire war."[161] The visual identification requirement forced American pilots to fly closer to the enemy aircraft,

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[155] Andreas Parsch, "Raytheon AAM-N-2, 3, 6/AIM-101/AIM-7/RIM-7 Sparrow," Andreas Parsch, 2007, last modified April 13, 2007, accessed March 18, 2016, http://www.designation-systems.net/dusrm/m-7.html.

[156] Westrum, *Sidewinder*, 209.

[157] Lambeth, *The Transformation of American Air Power*, 43.

[158] David R. Mets, *Checking Six Is Not Enough: The Evolution and Future of Air Superiority Armament* (Maxwell Air Force Base, AL: Air University Press, 1992), 28.

[159] Westrum, *Sidewinder*, 211.

[160] Werrell, *Chasing the Silver Bullet*, 43.

[161] Werrell, *Chasing the Silver Bullet*, 43.

negating the principle advantage of the Sparrow missile, and compromising the entire concept behind the F-4 Phantom.

The period between the Korean War and Vietnam provided an opportunity for US doctrine and policy to incorporate the lessons learned from fighting a limited war in Korea and adjust acquisition programs accordingly. Instead, the *New Look* was very similar to the post-World War II doctrine. As such, the focus was on nuclear weapons and even the TAC shifted towards nuclear employment. The lack of overall weapon development was again remarkable. Because of the duration of the Vietnam War, there was time to develop new air-to-ground munitions that ultimately made an impact on the conflict. "The introduction of guided bombs added a new dimension to modern air warfare … A target in the middle of a densely populated region could be hit with nearly surgical precision."[162] The Paveway program presented the increased survival of aircraft executing these missions as an additional facet. "The fact that no Paveway aircraft were lost during the early years of implementation was a boon not only for the aircrew involved but also for military and government leaders faced with an increasingly unpopular war."[163] Unfortunately, there was "no answer to the problem of interdiction against Marxist-style guerillas" throughout the war.[164] An additional problem highlighted in Vietnam's ground-attack operations "was that American air power was never reliably effective at night."[165] The ground-attack munitions evolved to the point they provided policy makers' options and military planners the effects required on the battlefield. The same cannot be said of the fight for air dominance.

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[162] Breitling, *Guided Bomb Operations*, 34.

[163] Gillespie, *Weapons of Choice*, 14.

[164] Doglione et al., "Airpower and the 1972 Spring Invasion," 112.

[165] Lambeth, *The Transformation of American Air Power*, 41.

The American performance in attempting to gain air dominance in Vietnam was underwhelming. “In contrast to the great successes in both World War II and Korea, the Air Force was unable to exercise air superiority for more than brief periods and even by its own accounts was barely able to achieve a favorable air-to-air kill-to-loss ratio.”[166] One could argue this was due to targeting limitations and policy constraints. While the doctrinal approach at the time was to bomb enemy airfields, “such permission never came,” and the USAF was forced to engage the MiGs in the air.[167] Fear of escalation denied the military the ability to use its concept of warfare. The military had difficulty adapting to the detriment of military effectiveness. The doctrine focused on disabling the enemy forces through nuclear attack, and as such, the focus on training was geared towards nuclear attack. The platforms acquired were not maneuverable, as dogfighting was thought to be outdated. Further complicating issues, the main advantage for the American forces was the range of the AIM-7, but this was limited by operational restraints and the lack of effective IFF systems. Adapting either platforms or weapons for aerial combat success proved difficult, and did not make a significant impact in Vietnam.

The execution of Vietnam did not match the expectation of the military. Tactical fighters flew the strategic interdiction missions while the strategic bombers flew close air support missions. “The Vietnam War in general, underscore[d] the point that technology must be appropriate for conditions. The Thunderchief was an excellent aircraft for the mission for which it was designed but a poor one for the mission it actually flew. The long time between design and employment and the varied missions required of Air Force aircraft exacerbated the problem.”[168] The policy and vision of future wars affect research, development, and acquisition. All of these

[166] Werrell, *Chasing the Silver Bullet*, 42.

[167] Burbage et al., “The Battle for the Skies,” 241.

[168] Werrell, *Chasing the Silver Bullet*, 15.

factors create a lag before a new conceptualization of warfare is effectively executable. Vietnam "revealed the consequences of the nation's previous fixation on nuclear strategy at the expense of adequate preparations for conventional war. It further showed the costs of having goals with less than abiding clarity on the policy front."[169] Once again, platform development proved most effective. The overconfidence of the AIM-7 and its influence on the F-4 design was actually a detriment to the Phantom's success in Vietnam. Another emerging theme was the idea of adaptable platforms with the ability to accept new weapons as the conflict evolved. The F-4 transitioned from a pure interceptor for the US Navy into a fighter-bomber for the USAF. The B-52 missions adapted from strategic bombing to close air support. Weapon development lagged before the war, but new bombs were developed through the conflict that enabled policy. The shorter time required to develop weapons mitigated their lack of development prior to the war.

The Right Tools for the Job: Operation Desert Storm

The core tenets of Air Force doctrine remain unchanged after the Vietnam War, but the primacy of nuclear weapons in doctrine did change. The overwhelming focus on nuclear weapons was no longer sufficient to meet policy needs. Doctrine continued to espouse, "The basic objective of aerospace forces [was] to win the aerospace battle-to gain and/or maintain control of the aerospace environment and to take decisive actions immediately and directly against an enemy's warfighting capacity."[170] After Vietnam, the USAF again recognized the need to focus on air superiority, followed with attacking the enemy's warfighting capability. "The first consideration in employing aerospace forces is gaining and maintaining the freedom of action to conduct operations against the enemy. An air commander usually gains this freedom by taking

[169] Lambeth, *The Transformation of American Air Power*, 49.

[170] Air Force Manual (AFM) 1-1, *Basic Aerospace Doctrine of the United States Air Force* (Washington, DC: Government Printing Office, 1984), 1-3.

the necessary steps to control the aerospace environment."[171] With air superiority secured, the doctrine called for striking at the enemy's warfighting capacity, a continuity throughout Air Force history. In this vein, the USAF specified both strategic and tactical action through the air. "Strategic actions produce effects and influences which serve the needs of the overall war effort; tactical actions produce direct effects on the field of battle."[172] The Air Force was not the only service reevaluating its warfare concepts after Vietnam.

The US Army also codified a new doctrine post-Vietnam. AirLand Battle was the culmination of this effort. The doctrine focused on the most important scenario for national survival, although least likely: a mechanized war in NATO Europe.[173] "The codified doctrine placed primary emphasis on maneuver, counterattack, and the ability to keep the enemy off balance," using airpower to attack second echelon forces to preserve a maneuver advantage for American ground forces.[174] The naming of the Army doctrine was ingenious. "The name AirLand Battle implied that there was cooperation and agreement between the Army and the Air Force, but in fact the doctrine was a unilateral development of the Army."[175] While the doctrine was strictly that of the Army, its existence did enhance the interoperability of the two services' concepts.

The Air Force did agree to conduct joint exercises using the AirLand Battle concept with the Army. The Air Force signed a memorandum of understanding (MOU) in April 1983, with the conclusion "that the services working together under the MOU would improve the effectiveness of joint operations and help to iron out doctrinal differences between the Air Force and the

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[171] AFM 1-1, 2-11.

[172] AFM 1-1, 2-11.

[173] Robert Frank Futrell, *Ideas, Concepts, Doctrine, Vol. II, Basic Thinking in the United States Air Force, 1961-1984* (Maxwell Air Force Base, AL: Air University Press, 1989), 548.

[174] Futrell, *Ideas, Concepts, Doctrine, Vol. II*, 551.

[175] Futrell, *Ideas, Concepts, Doctrine, Vol. II*, 551.

Army."[176] One of these differences was the overarching view of interdiction throughout a campaign. The history of airpower from World War II through Vietnam led to interdiction being "identified almost solely with reducing the flow of men and materials."[177] Air Force doctrine still envisioned using strategic bombing to attack "against the vital elements of an enemy's war sustaining capabilities and his will to wage war."[178] To conduct this type of campaign required air superiority, and the ability to strike heavily defended targets deep within enemy territory.

As technology progressed, the requirements for fighter and strike aircraft began diverging. Vietnam highlighted this deviation and changed the Air Force's view of platform procurement priorities. In fiscal year 1972, the Air Force announced it was moving towards a force made up of specialized aircraft like the F-15 and A-X, eventually becoming the A-10, to "meet the critical demands of mission effectiveness at the extreme end of the performance spectrum."[179] The days of a single strike fighter were ending. The F-15 Eagle was designed for air superiority. Doctrine specified, "The most precious thing aerospace forces can provide for an army or navy is control of the aerospace environment, since this enables surface forces to carry out their own plan of action without interference from an enemy's aerospace forces."[180] Air superiority was not only for the benefit of the Army and for the benefit of the Navy. Air superiority opened the door for strategic attack. Air Force doctrine focused on these attacks as most beneficial, while acknowledging the political constraints:

> Attacks against heartland targets can produce benefits beyond the proportion of effort expended and costs involved. For this reason, an air commander must seize every opportunity to execute heartland attacks, but there are many considerations in taking

[176] Futrell, *Ideas, Concepts, Doctrine, Vol. II*, 554.

[177] Futrell, *Ideas, Concepts, Doctrine, Vol. II*, 547.

[178] AFM 1-1, 2-11.

[179] Futrell, *Ideas, Concepts, Doctrine, Vol. II*, 556.

[180] AFM 1-1, 2-12.

> these actions. These attacks may be limited by overriding political concerns, the intensity of enemy defenses, or more pressing needs on the battlefield.[181]

The renewed focus on air superiority and conventional strategic attack guided the Air Force procurement programs throughout the 1980's. Saddam Hussein's invasion of Kuwait provided the opportunity to test the results.

On August 2, 1991, Iraqi military forces moved across their southern border and seized Kuwait.[182] American policy towards the invasion quickly formed over the next several months. By August 8, President George H. W. Bush "demanded an immediate withdrawal of Iraqi troops from Kuwait and the restoration of the legitimate government."[183] National policy evolved beyond the limited goal of liberating Kuwait. "Saddam was a threat to the Middle East, and unless the United States did something to reduce or remove that threat, Iraq would continue to be a destabilizing factor in the region."[184] Policy turned towards longer-term stability with a goal of removing the destabilizing presence in the region. National policy shifted towards "neutralizing Iraq, removing the threat, removing [Saddam Hussein's] weaponry and his power to make war."[185] The war was limited, but aimed to liberate Kuwait and destroy Iraq's military capability. With policy set, the Air Force deployed its revamped conceptualization of warfare and the platforms and weapons developed since the Vietnam War.

The evolution of the F-15E Strike Eagle began in Vietnam. The Air Force's "appreciation that neither the F-105 nor the F-4 could turn with the more maneuverable MiGs ultimately

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[181] AFM 1-1, 2-12.

[182] Gordon Martel, ed., *Twentieth-Century War and Conflict: A Concise Encyclopedia* (Malden, MA: John Wiley & Sons, 2015), 85.

[183] Donaldson, *America at War Since 1945*, 160.

[184] Donaldson, *America at War Since 1945*, 160.

[185] Donaldson, *America at War Since 1945*, 160-161.

contributed to a later requirement for the far-more agile F-15 as a pure air superiority fighter."[186] The focus for the F-15 as an air superiority platform was so strong that the program office had a banner reading "Not a pound for air to ground."[187] In October of 1982, the Office of the Secretary of Defense directed the Air Force to find its next dual-role fighter.[188] The Air Force needed a platform to eventually replace the F-111 and carry out attacks against second echelon Soviet forces prescribed in both Army and Air Force doctrine. Air Force Chief of Staff General Charles Garbriel said he wanted the "E-model" to fly low-level, at night, and attack second echelon forces before they fan out and approach the front.[189] On February 24, 1984, the McDonnell-Douglas F-15E Strike Eagle defeated the General Dynamics F-16XL the fly-off competition.[190] It would take nearly six years before the platform was operational.

The F-15E was not a simple modification of the traditional air superiority based F-15. The aircraft had a strengthened structure, Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) pod, and conformal fuel tanks, but retained similar handling and flight performance of the traditional F-15.[191] The navigation system allowed for terrain following radar, which enabled the platform to fly low altitude and decrease the amount of time it spent susceptible to air defenses. The fuel tanks increased the range of the aircraft, enabling deep attacks, and permitted "a high speed dash during the attack or for survivability against enemy defensive systems," further decreasing the amount of time it is susceptible and increasing

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[186] Lambeth, *The Transformation of American Air Power*, 43.

[187] Richard Hallion, *Storm Over Iraq: Air Power and the Gulf War* (Washington: Smithsonian Institution Press, 1992), 291.

[188] Hallion, *Storm Over Iraq*, 291.

[189] Futrell, *Ideas, Concepts, Doctrine, Vol. II*, 565.

[190] Futrell, *Ideas, Concepts, Doctrine, Vol. II*, 565.

[191] Hallion, *Storm Over Iraq*, 292.

survivability.[192] The F-15E enhancements transformed an air superiority fighter into a true multirole aircraft.

The USAF needed another multirole platform, and the Strike Eagle provided that capability. One key difference between the F-15E and previous multi-role platforms was the overarching design. The F-15E was a derivative of an air superiority fighter, rather than a bomber-centric design. “The air-to-air capabilities [were] not impaired by the air-to-ground enhancements.”[193] This made it more survivable, and provided more flexibility to operational planners as a true multirole platform. The flexibility allowed planners to use the F-15E without escort aircraft, or even use them in an air superiority role if required. This flexibility enhanced the efficacy of the USAF by increasing the total number of air superiority platforms and precision attack platforms. The aircraft also boasted a large payload for a fighter-bomber.

Once operational, the Strike Eagle boasted the most diverse payload of the multi-role aircraft. The platform could carry 1,000 pounds more than the F-111F it would eventually replace, as well as all of the air-to-air missiles in the US inventory.[194] Its air-to-ground payload was just as diverse. Upon entering service, the F-15E could “effectively deliver all current air-to-surface weapons in the inventory.”[195] Especially important to the operational planners, the platform was capable of carrying precision-guided munitions, something that proved vital during war. The Strike Eagle was heavily tasked with hunting and destroying Iraqi tanks and Scud

[192] Robert C. Grosvenor, “The USAF F-15E (Strike Eagle): Air Support for the AirLand Battle-Future Concept” (master’s monograph, School of Advanced Military Studies, 1991), 24, accessed March 22, 2016. http://cgsc.contentdm.oclc.org/cdm/singleitem/collection/p4013coll3/id/1676/rec/1.

[193] Michael J. Gething, *Modern Fighting Aircraft. Vol. I, F-15 Eagle* (New York: Arco Publishing, 1983), 59.

[194] Grosvenor, “The USAF F-15E,” 25.

[195] Grosvenor, “The USAF F-15E,” 23.

missile launchers, helping to fulfill overall campaign objectives.[196] While the F-15E was interdicting Iraqi ground forces, another new platform carried out strategic attack missions.

The F-117A Nighthawk represented a drastic departure from previous platform designs. The aircraft achieved survivability through signature management. The technology demonstration program, referred to as *Have Blue*, was initiated on April 26, 1976.[197] Every facet of the design centered on minimizing the signature of the aircraft. The vehicle shaping that allowed for the dramatic decrease in radar cross section also resulted in a statically unstable platform.[198] To overcome this problem, designers relied on fly-by-wire system modified from the F-16. Signature reduction was not limited to the shaping of the vehicle. The F-117A also incorporated radar absorbent material, further minimizing radar returns.[199] The F-117A allowed for strategic bombing without first destroying air defenses. During Operation Desert Storm, the platform showed near invisibility to Iraqi radar while attacking Iraq's most sensitive targets.[200] The investment in stealth proved worthwhile as "all the F–117As returned safely to base."[201] The increase in survivability did have tradeoffs.

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[196] Barry D. Watts and Thomas A. Keaney, *Gulf War Air Power Survey, Vol. II, Part II, Effects and Effectiveness* (Washington, DC: Government Printing Office, 1993), 209.

[197] David C. Aronstein and Albert C. Piccirillo, *Have Blue and the F-117A: Evolution of the "Stealth Fighter"* (Reston, VA: American Institute of Aeronautics and Astronautics, 1997), 33.

[198] Aronstein and Piccirillo, *Have Blue*, 72-73.

[199] Aronstein and Piccirillo, *Have Blue*, 171.

[200] US Air Force, History and Museums Program, *On Target: Organizing and Executing the Strategic Air Campaign Against Iraq*, by Richard G. Davis (Washington, DC: Government Printing Office, 2002), 178, accessed March 19, 2016, http://www.afhso.af.mil/shared/media/document/AFD-100928-035.pdf.

[201] Davis, *On Target*, 186.

The F-117A provided no flexibility in its employment concept. The platform was designed to penetrate enemy air defenses and deliver precision weapons. The increased survivability resulting in an unstable platform with a limited flight profile restricted many other options for the F-117. One concept presented was using the platform to penetrate enemy defenses and attack larger Soviet airborne early warning aircraft.[202] This concept, which was never tested, included using the AIM-9 to provide an air-to-air capability.[203] Ultimately, the ability to have a stealthy platform was attainable, with significant restrictions. These restrictions drove requirements, and "night, clear air capability" became the request.[204] The constraint to minimize the platform's signature also limited the platform's payload.

To preserve the low radar cross section, the F-117A had to carry its weapons internally. The platform design called for an internal weapons bay with two weapons, and a 5,000 pound payload.[205] The limited number of weapons presented a serious limitation for the F-117. "The precision guided munition (PGM) initially specified for the F-117A at initial operational capability was the guided bomb unit (GBU)-10 laser guided bomb, which utilized a 2000 lb Mk-84 body, a fin unit on the tail and a Paveway II guidance kit on the nose."[206] The most advanced platform in the inventory was designed to use Vietnam era weaponry.

Unfortunately, during this period, "weapons integration tended to lag aircraft development."[207] Additionally, the security requirements around the F-117A created difficulties

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[202] Aronstein and Piccirillo, *Have Blue*, 158.

[203] Aronstein and Piccirillo, *Have Blue*, 158.

[204] Aronstein and Piccirillo, *Have Blue*, 158.

[205] Aronstein and Piccirillo, *Have Blue*, 67.

[206] Aronstein and Piccirillo, *Have Blue*, 140.

[207] Aronstein and Piccirillo, *Have Blue*, 160.

in trying to match requirements with weapons programs. "The weapon that seemed ideally suited to the F-117A's concept of operations (GBU-24), was under development concurrently with the F-117A, but would not fit in the F-117A's internal weapons bays. An aggressive effort was undertaken by a small number of individuals to address this situation."[208] The deficiency ultimately led to the GBU-27 discussed below.[209] Other than tankers for aerial refueling, "the F-117A's combination of extreme accuracy and operational invisibility made it … the most important aircraft in the offensive air campaign."[210] The entire efficacy of the F-117A was dependent on the effectiveness of the weapons it employed.

One of the lessons the Air Force learned in Vietnam was the value of precision weapons. This was reinforced in a 1976 RAND study regarding precision weapons:

> [Precision weapons] provided the morally attractive and mutually beneficial possibility of disabling military targets without collateral damage, thus offering the political leadership a variety of military options to fit 'the tone and intent of the political discourse.' And, second, they greatly reduced the necessity for using nuclear weapons in certain cases—namely those in which warhead lethality was being used to compensate for inaccurate delivery—thus raising the nuclear threshold.[211]

Precision weapons provided options and were key for the new concept of warfare. Unlike previous time periods, conventional weapon development continued after the Vietnam War.

The Paveway guidance system proved accurate and easily combined with bombs of various sizes. The USAF continued developing the program after its success in Vietnam. The next version, Paveway III was the answer for TAC's 1976 request for a laser-guided bomb "that could be delivered at high speeds and low levels."[212] One of the problems with the previous guidance

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[208] Aronstein and Piccirillo, *Have Blue*, 160.

[209] Aronstein and Piccirillo, *Have Blue*, 160.

[210] Davis, *On Target*, 91.

[211] Gillespie, *Weapons of Choice*, 127.

[212] Werrell, *Chasing the Silver Bullet*, 154.

systems was their use of so-called *bang-bang* guidance. Paveway II used full deflections of the steering canards, which often resulted "in a flat, slow terminal approach to the target."[213] Under these conditions, the GBU-10, a 2,000-pound Mk-84 bomb with Paveway II guidance system attached, "frequently had a high angle of attack, low impact velocity and poor impact angle—factors that degraded its accuracy and its ability to penetrate harder targets."[214] The Paveway III system increased the range of the weapon as well as the accuracy, in part by eliminating the *bang-bang* guidance of previous versions.[215] Testing on Paveway III finished in March 1986 with 44 out of 47 successful strikes.[216] Because of the increased cost of Paveway III, the legacy Paveway II was still employed in Operation Desert Storm. Both proved accurate, but depending on the target, even the 2,000 lb bomb proved to have an insufficient yield.

The Paveway II was typically used on smaller bombs, while the more expensive Paveway III was attached to larger Mk-84 2,000-pound and BLU-109 bomb bodies, known as the GBU-24.[217] This weapon was far too expensive to employ on single tanks. The weapon of choice for striking Iraqi armored vehicles was the GBU-12. The bomb consisted of a 500-pound Mk-82 bomb and the Paveway II guidance system. The accuracy of the unit was sufficient to kill a main battle tank in the open, but not against the tanks shielded by sand berms.[218] In these cases, the actual ratio of bombs per kill was closer to one-in-three, which "was a considerable tactical

[213] Aronstein and Piccirillo, *Have Blue*, 141.

[214] Aronstein and Piccirillo, *Have Blue*, 141.

[215] Richard J. Blanchfield et al., *Gulf War Air Power Survey, Vol. IV, Part I, Weapons, Tactics, and Training* (Washington, DC: Government Printing Office, 1993), 76.

[216] Werrell, *Chasing the Silver Bullet*, 155.

[217] Blanchfield et al., *Weapons, Tactics, and Training*, 76.

[218] Watts and Keaney, *Effects and Effectiveness*, 36.

achievement in its own right."[219] While accuracy improved dramatically compared to previous conflicts, the enemy was able to shield equipment to mitigate the effects from the smaller yield of the weapon. The GBU-12 was not the only munition that was unable to meet expectations.

Another area of weapon advancement was the ability to strike hardened structures. The Mk-84 "was not suitable for penetrating buried, reinforced concrete target. Ricochets, broaches, and premature breakup of the case were not uncommon."[220] The Air Force required a penetrating capability to continue its concept of strategic bombing, as many high-value targets were either buried or hardened. "In 1985, a newly developed 2,000 pound hard target penetrator bomb, the BLU-109, entered service with the Air Force, providing a popular, interchangeable alternative to the Mark 84 for certain targets."[221] This bomb body provided a penetrating capability with the accuracy of the Paveway III guidance system. The match seemed perfect for the F-117A, but the bomb would not fit in the Nighthawk's weapons bay, as the tail fins were too large.[222] Fortunately, this discrepancy was discovered in development.

The GBU-27 was designed specifically for the F-117A to provide high accuracy and penetration capability for the stealth platform. The weapon consisted of "a BLU-109 bomb with a low-level laser-guidance kit. It has a modified GBU-24 seeker head and a smaller GBU-10 tail assembly necessary for internal carriage." [223] The weapon had the accuracy of the Paveway III with the ability to penetrate reinforced concrete. "The F-117A/GBU-27 combination made its operational debut in Desert Storm in 1991, demonstrating unprecedented accuracy" of over 95%

[219] Watts and Keaney, *Effects and Effectiveness*, 36.

[220] Aronstein and Piccirillo, *Have Blue*, 141.

[221] Gillespie, *Weapons of Choice*, 137.

[222] Aronstein and Piccirillo, *Have Blue*, 143.

[223] Blanchfield et al., *Weapons, Tactics, and Training*, 76-77.

probability of hit.[224] "Few targets in Iraq could survive one or two correctly aimed GBU-27s."[225] There were some targets that even the GBU-27 could not destroy.

Several bunkers in Iraq withstood attacks from the GBU-27. To solve this problem, United States Air Forces Central (CENTAF) turned to weapons developers to find a solution:

> CENTAF did request immediate development of a new bomb, utilizing off-the-shelf technology. Normally a new bomb would have taken years to develop. Under the pressure of war, the U.S. weapons development community produced four GBU-28s in a month. Their bodies were at one time artillery gun barrels, and each weighed nearly 5,000 pounds. They went to Nevada for testing. The first GBU-28 missed a concrete slab but penetrated deeply into the soil, the second penetrated concrete without breaking up … the fourth [GBU-28] penetrated the bunker.'"[226]

Once again, when weapon yield or destructive power was insufficient, successful modifications were made during the conflict. Successfully targeting the command and control bunkers meant all Iraqi targets were at risk of attack by airpower.

Precision weapons proved key to US success throughout Operation Desert Storm. In preparation for the conflict, the planners alleviated the President's concern regarding sensitive targets with sound tactics and precision weapons.[227] In six weeks, "the U.S. military dropped over 9,500 laser guided bombs alone—more than double the number released over North Vietnam from 1968 to 1972."[228] While this is a dramatic increase over Vietnam, precision weapons accounted for only eight percent of the total bombs expended, but caused "well over 75 percent of the serious damage inflicted on Iraqi targets."[229] The weapons and platforms developed after the

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[224] Aronstein and Piccirillo, *Have Blue*, 144.

[225] Davis, *On Target*, 91.

[226] Williamson Murray, *Gulf War Air Power Survey, Vol. II, Part I, Operations* (Washington, DC: Government Printing Office, 1993), 240.

[227] Davis, *On Target*, 105.

[228] Gillespie, *Weapons of Choice*, 137.

[229] Gillespie, *Weapons of Choice*, 138.

Vietnam War were well suited to the nature of warfare in Operation Desert Storm. Platforms provided options for policy makers rather than constraints. In the few situations where there were no good solutions to destroy a target, weapons development during the war solved the problem.

Airpower delivered on its doctrinal requirements in Operation Desert Storm. Air superiority was achieved, allowing freedom of maneuver in the sea and on the ground. "At the end of the war, there was no doubt that Iraq had suffered a crushing military defeat and that air power was the decisive factor in bringing that about."[230] The combined use of the F-15E and F-117A with complimentary precision weapons proved successful in both doctrinal terms, and providing the right means for national policy. The main enabler of policy was the platform development preceding the war. The Nighthawk provided the ability to strike any target without expending effort ton destroying air defenses. While the F-117A was reliant on an effective weapon to achieve this feat, it was the platform that was critical to have at the start of the conflict. The F-15E enabled interdiction without creating additional sortie requirements for air support.

Go to War with the Air Force You Have

Several trends from the historical analysis demonstrate that development and employment of platforms, rather than weapons is most important for effectiveness on the modern battlefield. The first trend is the impact of national policy on the military. National security policy affects how the Air Force views its role in national defense and the nature of future conflicts. Following World War II and Korea, defense policy supported the concept of nuclear bombing in warfighting. The Air Force directed research, development, and acquisition toward this concept of warfare. As history shows, the national policy was not predictive, and both the Korean War and the Vietnam War were fought as conventional conflicts with politics limiting the nature of the

[230] Watts and Keaney, *Effects and Effectiveness*, 104.

conflict in order to prevent escalation. Predicting the next conflict is difficult to impossible, and stated national policy does not always align with the political reality of war.

Viewing war as political dialogue helps to understand just how important it is to control the nature of the conduct of the war. The way a war is fought sends a message to all of the various audiences observing the conflict. These include the adversary, other interested parties, and one's own population at home. The military means available at the time a given war breaks out are limited to the equipment procured up to that point. In this way, past policy and conceptualization of fighting limit the policy options available at the outset of war. Either this constraint limits policy makers' ability to clearly express their intent through the acts of war, forcing them into undesirable decisions; or more likely, it forces the military to use equipment that is not optimized for the conduct of the war at hand. The Vietnam War is one case of the latter. National defense policy changed from the nuclear doctrine prescribed in the *New Look* to more limited wars. The development and acquisition of equipment did not have the time to adjust before war broke out. In this case, the F-105 fighter-bomber designed to deliver nuclear weapons, was instead fighting a limited war over Vietnam. The Air Force did not have the means required to execute the war in the way policy makers desired.

One reason for the Air Force's unpreparedness is the inherent lag that occurs when the national conceptualization of warfare changes. Once a new concept is devised, there is a new cycle of research, development, and acquisition that must occur before the military is equipped to fight in this new style. Until the new equipment is procured, there is risk in either limiting options for policy makers, or forcing the military to fight with suboptimal equipment designed for a different type of conflict. As technology advances, the lag increases further. The aircraft available during Operation Desert Storm took, on average, thirteen years from the initial developmental concept until platform fielding. In the case of the F-22 Raptor, that time increased to twenty-four

years.[231] As the lag increases, the chance of future risk increases unless the platform and weapon development is intentionally forward looking.

Vulnerability results when platforms and weapons are incapable of quickly adapting to new policies. While both are important to overall effectiveness, the platform proves most important for development. The critical factor is the amount of time required to develop a new platform versus the time required to develop a new weapon. In the historical examples provided, shortfalls in weapon development were mitigated during the course of the conflicts. The same cannot be said of the platforms. Since new platforms are not a realistic option at the outset of war, and the nature of future wars are not predictable, platforms must be adaptable to an unknown future.

An adaptable platform has all of the characteristics examined above; survivability, flexibility, and sufficient payload. Additionally, an adaptable platform must have slack capability in all of its design characteristics. An adaptable platform is one that does not maximize the ability of the airframe and engines right off of the assembly line, because doing so restricts future adaptation and limits the platforms ability to adjust to the unknowns on the modern battlefield. The platform must have the ability to carry additional weight for new sensors or weapons. The platform must also have the physical space for additional sensors, as well as the computing power, electrical power, and heat dispersion capability to accept these new sensors. In short, the design must allow for future system integration without redesigning major airframe components. The F-4 Phantom proved adaptable during the Vietnam War, and proved critical for the Air Force's mission. The long-range naval interceptor was used for dogfighting, as well as tactical bombing missions. The ability to add weapons, sensors, and even a gun pod was vital for mission effectiveness.

[231] Bill Sweetman, *F-22 Raptor* (Osceola, WI: Motorbooks International, 1998), 94.

Platform development and employment provides greater effectiveness on the modern battlefield. Because national security policies are fluid, and it is impossible to predict the next war. Military planners will enter a war with the weapon systems already in the inventory, and must fulfill the policy makers' intent with those systems. Platforms require more time to develop, making quick development during a conflict unrealistic. The historical analysis reinforces this, as the US Air Force does not introduce new platforms into a contested environment during the conflicts analyzed. Instead, the Air Force adapts its existing platforms and develops new weapons to meet the needs of policy makers and military planners. The complexity of platforms prohibits rapid development. The aircraft developed today are the assets military planners will use to accomplish future policy objectives. These platforms must provide options to execute future national strategies.

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